Evaluation of monitoring methods for western flower thrips, *Frankliniella occidentalis* (Thysanoptera: Thripidae), during the blossom period of 'Granny Smith' apples

S.J. BRADLEY AND D.F. MAYER

DEPARTMENT OF ENTOMOLOGY, WASHINGTON STATE UNIVERSITY, PROSSER, WA 99350

ABSTRACT

Commercial sticky board traps (150 x 100 mm) of three different colors (blue, white or yellow) were treated with one of two chemical attractants (p-anisaldehyde and ethyl nicotinate) and with the solvent ethanol. Blue and white traps caught four and three times more thrips respectively than yellow traps. Attractants improved catches by only about 20% and were not considered economical. If traps are used, a plain blue trap is recommended. Trapping, beating tray and flower cluster flicking monitoring methods were compared. Trapping gave a time-averaged indication of thrips numbers, but numbers are probably affected by location of the trap and flowering stage of the apple. The beating tray method was the most versatile. It could be used regardless of flower condition and produced instant results. The currently recommended flower cluster flicking method produced few thrips and is affected by condition and age of the flowers, as well as time of day. We conclude that it is an ineffective method. Monitoring thrips numbers after blossom using a beating tray may give more practical economic thresholds for treatment.

Key words: thrips, apples, *Frankliniella occidentalis*

INTRODUCTION

Western flower thrips (*Frankliniella occidentalis* (Pergande)) are small (1-2 mm) slender insects that feed on the flowers of many plants. They can cause damage on stone fruit by rasping the surface of the fruit as they feed. The main damage on apples is from females ovipositing in the young fruitlets, just after petal fall. The resulting puncture causes 'pansy spot', a whitish area around the oviposition site. This damage shows up mainly in light skinned varieties such as Granny Smith, but can also be a problem in Rome Beauty and McIntosh (Flint 1991).

Chemical control of thrips may not be required every year. If other plants are in flower at the same time, they may dilute the thrips population below damaging levels (Beers *et al.* 1993). Although the relationship between thrips population and fruit damage is unclear, the relationship can only be found by monitoring the thrips during critical periods. Once the relationship is found, monitoring will show if control is required. Many monitoring methods require field samples to be taken and analyzed in the laboratory (Madsen *et al.* 1975). For most consultants this is not convenient, because growers need the results immediately. Most instant monitoring methods involve either sampling individual flowers (DeGrandi-Hoffman *et al.* 1988, Terry & DeGrandi-Hoffman 1988, Beers *et al.* 1993), or the use of a beating tray as used for sampling pear psylla (N. Simone personal communication).

The objectives of this study were to compare different sampling methods and times and to evaluate colored sticky board traps. We also assessed thrips damage in the fruit.

MATERIALS AND METHODS

The 'Granny Smith' apple orchards used had either a previous history of thrips pests, or blocks where thrips had been found during flowering. They were at Moxee, Zillah, Prosser, Pasco (Sagemoor) and Mattawa, WA. All orchards used conventional insecticide pest control programs, except for the Mattawa orchard which used organic controls.

Three monitoring methods were examined. The first involved sampling individual flower clusters (Beers *et al.* 1993). Five clusters from five trees were picked and individually given three vigorous shakes (or 'flicks') into a white plastic cup and the total number of thrips recorded.

Table 1

The effect of color and attractant on mean (n = 72) daily number of total thrips caught. Means with the same letter are not significantly different at $p < 0.05$ (log (x+1) transformation).

Factor		Daily trap catch
Colour	blue	41.3a
	white	34.9b
	yellow	10.6c
Attractant	p-anisaldehyde	33.4a
	nicotinate	27.9ab
	none	25.4b

In the second method thrips were sampled by jarring them from a limb onto a white cloth tray and counting them. A 46 cm (18") square cloth beating tray was held under a nearly horizontal section of limb ¾ to 1¼ inch in diameter with an average complement of flower clusters. The limb was tapped firmly three times with a 1-foot length of rubber hose. Twenty-five randomly selected sites on 25 trees were sampled throughout the block and the total number of thrips recorded.

The third method used blue, white and yellow colored sticky traps. Also, Teulon *et al.* (1993) mentioned trap catch enhancement with the use of chemical attractants. We looked at both color and attractants as a sub-study within this evaluation. The traps were 10 x 15 cm Chroma line card traps produced by Phero Tech Inc., 7572 Progress Way. Ladner, B.C. Three colors were examined: non U.V. white (No. 201); bright blue (No. 411); and bright yellow (No. 611). A chemical attractant, either p-anisaldehyde or nicotinic acid ethyl ester (Sigma Chemicals, POB 14508, St. Louis, MO) were each sprayed on 112 different cards.

Each attractant was mixed as a 40% solution in 95% ethanol as described in Teulon *et al.* (1993). The control was 95% ethanol. Attractants were applied to both sides of card traps using one 'squirt' (emitting 0.8 ml) per side from a plastic spray bottle, held about 10 cm away.

Traps were hung within foliage at about two-thirds of the height of the tree (between 1.0 and 1.8 m) . At each sub block three blue traps, three blue traps treated with p-anisaldehyde, three blue traps treated with nicotinic, three white traps, three white traps treated with p-anisaldehyde, three white traps treated with nicotinic, three yellow traps, three yellow traps treated with p-anisaldehyde and three yellow traps treated with nicotinic were hung on trees. Trees were selected randomly and traps placed randomly. After a period of 3-5 days the numbers of all visible thrips (all life stages and both sexes) were recorded and new traps randomly placed.

Damage was assessed on 6 July at Sagemoor, Mattawa and Moxee and 12 July at Zillah. One hundred fruit were examined on five trees in each sub-block, and the number with one or more pansy spots was recorded.

Data from the effect of color and chemical attractants on trap catch study, were transformed using log (x+1) and analyzed using General Linear Model in SAS. Site and time were included as factors.

RESULTS AND DISCUSSION

During the 1994 blossom season, relatively few thrips were found in south central Washington. In some orchards that previously had a thrips problem, none could be found during blossom. The orchard in Prosser and one in Zillah were dropped from the study due to a lack of thrips. In two of the orchards (Sagemoor and Mattawa), thrips were found relatively late in the flowering period.

At Sagemoor the traps were not replaced after counting on 18 April. The number of thrips caught during the 18-20 April period in Table 3 was obtained by subtracting the number caught in the 13-18 April period from the 20 April total. These data were not used in the analysis of variance in Table 1.

Blue caught more thrips than white and white more than yellow and the effect of color was significant at the $p < 0.001$ level (Table 1). The attractant p-anisaldehyde caught significantly ($p < 0.05$) more thrips than the check (Table 1). There was no significant differences between blue (the most attractive color) and attractants (Table 2).

Table 3 shows the relative numbers found using the three methods. Traps collected the most thrips but the beating tray method gave immediate results.

The Sagemoor Road orchard was monitored for the longest period and showed a rapid increase in thrips population (the beating tray method yielded 11 thrips on the first visit which rose to an average of 91 only one week later). The population later declined as expected (DeGrandi-Hoffman *et al.* 1988). Traps caught steadily increasing numbers of thrips over the whole period. The flower flick method at Sagemoor produced numbers that correlated with the beating tray method, but after petal fall is no longer a viable method since there are no flowers.

At Moxee, more thrips were collected using the flower flick method compared to other methods than at Sagemoor. This may be because trees at Sagemoor had more flowers per unit of limb than those at Moxee. The blue traps caught proportionately fewer thrips at Moxee than the other orchards, possibly because of the low flower and limb density, or the increased competition from a greater number of open flowers. As at Sagemoor, the late stage of flowering at Mattawa caused the traps to catch proportionately more thrips than the beating method.

Table 4 shows little difference in damaged fruit between the orchard blocks. The orchard at Zillah, while having no thrips present during flowering , had similar damage to the other blocks.

The best color for catching western flower thrips is still controversial. Even studies by one group of researchers can produce conflicting results. For example, Yudin *et al.* (1987) suggested white was the best color, yet one of their experiments showed blue catching the most. Our results support Moffit (1964), that white was far superior to yellow, but he did not test blue. We showed that white is superior to yellow, contrary to the statements of the manufacturers (Phero Tech, personal communication). Blue caught more thrips than white and it was easier to see the thrips and to locate the traps in an orchard full of white blossom where white traps were particularly difficult to find. These conflicting results may be due to subtle differences in the spectral qualities of the colors used and possibly to differences in the thrips population. Thrips in different areas or at different times of the year may move to flowers of different colors.

We did not see the 2-6 fold increase through the use of attractants that Teulon *et al.* (1993) found after applying anisaldehyde to sticky traps. This may be due to several factors. They used yellow traps, which are seldom the most attractive color. Our method of applying attractant differed from theirs, although we applied more attractant than them. Our study was conducted in the windy conditions of the field, while they conducted theirs in greenhouses, where it may be easier for thrips to fly towards an odor gradient. Wind would release more volatile attractants from the surface, while at the same time diluting its atmospheric concentration (Van der Kraan & Ebbers 1990). Anisaldehyde also formed yellow clusters of crystals on the surface of the sticky board, a possible reaction with the solvents used, and this may have reduced the 'stickiness' of the trap as well as diluting the effect of the attractant.

Attractants produced little benefit considering the effort required to apply them. Both attractants were skin irritants and the spray drift reddened arms and hands when they were applied. There was also more than one anisaldehyde spill, making travel an unpleasant olfactory experience.

Yudin *et al.* (1987) discussed attractive traps and found good correlation between numbers caught in contrasting colored traps and the thrips population in lettuce crops. We had no absolute method of determining population, but we considered that the beating tray most consistently indicated population levels. This method sampled a unit of branch area, and while this varied from orchard to orchard as tree management varied, it did not change in a single orchard over the sampling period. Variation between orchards, might make economic thresholds difficult to determine.

Compared with the results of the beating tray, the traps became more attractive near the end of flowering. This is probably when more thrips were leaving the apple trees. Traps give a time-averaged population estimate, since they 'smooth' variations of activity during and between

Table 2

The effect of attractants on daily total number of thrips caught in different colored traps. Means with the same letter for the same color trap are not significantly different at $p < 0.05$ (log (x+1) transformation).

Treatment	Blue	White	Yellow
Treated with p-anisaldehyde	41.8a	45.4a	13.6a
Treated with nicotinate	41.9a	34.4b	7.3b
Untreated	40.1a	13.6c	10.8ab

Table 3

Comparison of thrips monitoring methods for 'Granny Smith' apple blocks, at three Washington orchards.

Block	Date	Blossom[1]	Flower Flick[2]	Beating Tray[3]	Blue Traps[4]
Sagemoor – Both	13 Apr	35% PF	1	11	–
Sagemoor – E	18 Apr	60% PF	3	33	–
Sagemoor – W	18 Apr	55% PF	4	38	–
Sagemoor – E	20 Apr	70% PF	24	82	73
Sagemoor – W	20 Apr	60% PF	10	111	108
Sagemoor – E	25 Apr	99% PF	NF	31	129
Sagemoor – W	25 Apr	95% PF	NF	51	87
Moxee – Both	22 Apr	Full Bloom	9	30	–
Moxee – NW	26 Apr	20% PF	5	85	41
Moxee – SE	26 Apr	20% PF	11	69	31
Mattawa – NE	22 Apr	99% PF	NF	30	164
Mattawa – SW	22 Apr	99% PF	NF	49	129

1 PF = Petal Fall, NF = No Flowers

2 Flower flick method, total number of thrips found after flicking 25 flower clusters into a white paper cup.

3 Limb tapping method, total number of thrips found after 25 beating tray observations following three limb hits.

4 Blue trap method, daily average of total thrips caught in all nine blue traps.

– no collection

Table 4

Incidence of Pansy spot in samples of 500 fruit from 'Granny Smith' orchard blocks

Block	Pansy Spot
Sagemoor – E	2.4%
Sagemoor – W	2.2%
Moxee – NW	2.6%
Moxee – SE	2.0%
Mattawa – NE	4.0%
Mattawa – SW	1.6%
Zillah	2.0%

days. The catch may also be affected by density of flowers around each trap. Position may also affect the catch, and we noticed that traps in sunny positions caught more than those in the shade. These factors also make comparisons between different orchards difficult.

Madsen & Jack (1966) suggested that post petal-fall is the best time to spray for thrips, so monitoring at that time may give the best prediction of damage. The number of thrips caught may be related to number of flowers (or fruitlets) on a limb, which may make determining economic thresholds difficult. Beers *et al.* (1993) suggested that flower flicking should only be done in the late morning since thrips may only be on the flowers then. The beating tray method is not affected by this movement as the thrips probably only move on to neighboring leaves and branches. The beating tray method seemed to be the easiest and quickest and because it was probably not affected by time of day consultants could visit several orchards in a day.

The flower flick method yielded few thrips, and is affected by time of day (Beers *et al.* 1993). Consultants would therefore be at orchards only between 10 am and noon. The method can not be used once flowering is finished, even though it does give an actual number of thrips per flower, which may give a good estimate of potential damage. Late in the flowering period, flower flicks could yield abnormally high numbers because all thrips might be on the last remaining flowers. Hence flower flicks may not truly reflect relative risk of apple damage from the next generation of thrips. Madsen *et al.* (1975) used 20 thrips per 100 clusters (using a glass cylinder thrips extractor) as a treatment threshold, but found it did not keep damage below an acceptable level. Terry & DeGrandi-Hoffman (1988) found flower flicking less efficient than laboratory extraction methods, especially late in the blossom period. Numbers given by this method depend greatly on flower stage.

Damage to the apples was similar in all orchards. Terry (1991) found that oviposition (during flowering) did not increase significantly with the number of thrips, hence monitoring by any method may not be particularly useful. Terry's study ceased soon after petal fall. This is not the time of fruit damage but later in the season (as suggested by Madsen & Jack 1966).

Further work is needed to determine if the beating tray method gives consistent results at any time of day as we suspect it should. Monitoring populations during the flowering season and after flowering to see when thrips are in the trees would be useful to see if their presence later in the season can be related to damage. Populations of thrips were low in 1994. Other years might have high thrips numbers during flowering which could require preventative control at that time. Monitoring populations in more orchards during peak blossom and a few days after-petal fall, followed by an assessment of damage should indicate any correlation between numbers and damage.

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